## Response to the Letter to the Editor by Drs. Tschiersch and Haninger

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We thank Tschiersch and Haninger (*1*) for their comments on our analysis of temporal and spatial variation of radon measurements in dwellings in Gansu Province, China (*2*). Within the case–control study of lung cancer and residential radon, we conducted a sub-study to estimate uncertainties in radon (i.e. $^{222}Rn$) exposure assessment by placing three pairs of co-located detectors in each of several rooms of 55 dwellings for three consecutive years. Many of the dwellings were underground ''cave-type'' dwellings, and radon levels were notably high. In addressing uncertainties in radon exposure assessment, Tschiersch and Haninger take issue with our decision not to take any special account of uncertainties arising from the measurement device. Based on a components of variance analysis, our best estimate of the coefficient of variation (CV) was 0.50 (SE 0.02) for the temporal and spatial uncertainties in radon concentration measurements. It should be emphasized that our components of variance analysis included only one of the co-located detectors. Thus the estimate of CV = 0.50 for the overall uncertainty effectively includes variation from the measurement device. In our case–control analysis of lung cancer risk, we adjusted the excess odds ratios for temporal and spatial variations based on CV = 0.50 but also evaluated a range of CVs from 0.40 through 0.60. Our conclusion that the observed excess odds ratio (EOR) per Bq $m^{-3}$ should be increased by 50–100% to account for uncertainties in exposure assessment accords with uncertainty analyses in the UK (*4*) and in Sweden (*5*).

While our uncertainty adjustment of the EOR/Bq $m^{-3}$ incorporates uncertainty in detector measurements, we also stand by our conclusion that measurement uncertainty was a relatively small component of overall uncertainty. The CVs for the co-located detectors did indeed range as high as 0.6, as indicated by Tschiersch and Haninger; however, the mean CV for the co-located detectors was 0.1 (median 0.08), with 95% of the CVs for the co-located detectors under 0.3, 88% of CVs less than 0.2, and fully 61% of CVs less than 0.1. These results conformed closely with information from Howarth and Miles that indicated one standard deviation uncertainties for our Landauer-type track-etch detectors of 0.10 (*3*) and much below the 0.25 suggested by Tschiersch and Haninger.

Tschiersch and Haninger raise the issue of possible effects on measurements of radon from thoron gas ($^{220}Rn$), which may emanate from walls of dwellings and which has been measured in areas of loess soil like those found in our study region of Gansu (*6*). With a half-life of 56 s, the thoron gas concentration varies considerably and directly with distance from the walls, ceiling and floor, and any contribution of thoron to total radiation dose to target tissues in lungs of residents is likely minimal compared to radon gas, which is distributed more homogeneously throughout the dwellings. However, our exposure assessment was based on track-etch detectors that were placed 20–40 cm from ceilings, a relatively close distance and that may have recorded a small thoron component. If so, exposures would be slightly overestimated for radon, resulting in a slight underestimate of the EOR per Bq $m^{-3}$.

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